

## LATENCY NEGOTIATION IN A HETEROGENEOUS NETWORK OF SYNCHRONIZED SPEAKERS

### RELATED APPLICATIONS

[0001] This application is a continuation application of U.S. patent application Ser. No. 16/269,035, filed on Feb. 6, 2019, which is hereby incorporated by reference in its entirety.

### FIELD

[0002] Aspects of the disclosure generally relate to synchronized audio output from multiple speakers, and more specifically to techniques for negotiating latency in a heterogeneous network of synchronized speakers.

### BACKGROUND

[0003] Audio output devices such as audio speakers are available in several hardware configurations and can use a range of technologies for processing and rendering audio streams and for communicating with other devices, including audio input devices and other audio speakers. For example, speakers range from Bluetooth® speakers, Wi-Fi™ speakers, Audio for Video speakers (e.g., sound bars) and speakers that use other communication protocols. The wide array of speaker architectures, configurable speaker network topologies and communication technologies (e.g., Bluetooth, Wi-Fi etc.) used by the speakers to communicate with other devices makes interoperability and synchronization between speaker devices complicated and difficult to coordinate and execute.

### SUMMARY

[0004] All examples and features mentioned herein can be combined in any technically possible manner.

[0005] Aspects of the present disclosure provide a method performed by an audio source for negotiating latency in an audio network. The method generally includes receiving information regarding an audio processing latency associated with each of a set of two or more audio output devices connected to the audio network; determining, based at least on the received information, a maximum delay for outputting audio samples streamed by the audio source from the audio output devices in the set; determining, based on the maximum delay, timing for outputting the audio samples from the audio output devices in the set; and communicating the determined timing to the set of audio output devices for processing the audio samples in accordance with the timing.

[0006] In an aspect, the maximum delay includes a maximum time taken for an audio sample from the time the audio sample is output by the audio source to the time the audio sample is output by an audio transducer of an output device from the set.

[0007] In an aspect, the timing for outputting the audio samples includes a time, with reference to a reference clock, to output an audio sample from the output devices, wherein all output devices are time synchronized.

[0008] In an aspect, determining the maximum delay includes determining the maximum delay further based on a distribution latency to each audio output device from the set.

[0009] In an aspect, the distribution latency to an audio output device from the set is a function of a communication technology used for communication with the audio output device.

[0010] In an aspect, the audio source further communicates with a first subset of audio output devices from the set using a first communication technology and communicates with a second subset of audio output devices from the set using a second communication technology different from the first communication technology.

[0011] In an aspect, the audio source further obtains information regarding whether an audio output device from the set is configured for in-room operation or out-of-room operation.

[0012] In an aspect, the audio source further determines, based on the obtained information, that the audio output device is configured for in-room operation, wherein the audio output device outputs the audio samples in accordance with the timing, for output of the audio samples synchronized with output of the audio samples by other audio output devices from the set also configured for in-room operation.

[0013] In an aspect, the audio source further determines, based on the obtained information, that the audio output device is configured for out-of-room operation, wherein the audio output device, in order to achieve a best audio experience criterion, allows output of the audio samples with a phase shift from the audio samples output by one or more other audio output devices from the set configured for in-room operation.

[0014] In an aspect, the audio source further detects a change in configuration of the audio network, adjusts the timing for outputting audio samples from one or more of the audio output devices, based on the changed configuration, and communicates the adjusted timing to the audio output devices.

[0015] In an aspect, the audio source further determines that a communication technology used for a connection with at least one of the audio output devices is Wi-Fi technology, and buffers a portion of an audio stream before starting to transmit to the at least one device, wherein an amount of the buffered portion is based on the determined timing for outputting audio samples from the audio output devices in the set.

[0016] In an aspect, the audio source further communicates an indication of the determined timing to a video output device configured to output video synchronized with the audio output from at least one of the audio output devices from the set, and instructs the video output device to delay outputting the video to synchronize with the audio.

[0017] In an aspect, the audio source further decides to implement a lowest latency audio experience or a best audio experience based on a type of an input audio stream.

[0018] Aspects of the present disclosure provide an audio network. The audio network generally includes an audio source in communication with the audio output devices and configured to transmit a stream of audio samples for outputting by the audio output devices in the set. The audio source is generally configured to receive information regarding an audio processing latency associated with each of the set of audio output devices; determine, based at least on the received information, a maximum delay for outputting audio samples from the audio output devices in the set; determine, based on the maximum delay, timing for outputting the audio samples from the audio output devices in the set; and